THE EFFECT OF VARIOUS POSITION OF CIRCULAR HOLLOW SECTION ON THE STRENGTH OF FOAMED CONCRETE BEAM WITH PROCESSED SPENT BLEACHING AS PARTIAL REPLACEMENT OF CEMENT

AFIDATUL HUSNA MOHAMAD SYARIFF

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

_____

(Supervisor's Signature)

Full Name : Pn Rokiah Binti Othman

Position : Lecturer

Date : 21st June 2018

_____

(Co-supervisor's Signature)

Full Name :

Position :

Date :

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : Afidatul Husna Mohamad Syariff

ID Number : AA14125

Date : 21st June 2018

THE EFFECT OF VARIOUS POSITION OF CIRCULAR HOLLOW SECTION ON THE STRENGTH OF FOAMED CONCRETE BEAM WITH PROCESSED SPENT BLEACHING EARTH AS PARTIAL REPLACEMENT OF CEMENT

AFIDATUL HUSNA MOHAMAD SYARIFF

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2018

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Almighty Allah for His blessings and unending help. I would like to express my sincere gratitude to my supervisor, Puan Rokiah Othman for her guidance, advice and moral support. I would like to thank my family for their continuous support and encouragement. Finally, I thank my colleagues for helping and supporting me.

ABSTRAK

Pada masa kini, industri pembinaan memberi tumpuan kepada penggunaan bahan hijau yang mana satu prosesnya melepasi bumi, PSBE sebagai bahan pozzolan yang menawarkan lebih banyak tindak balas pozzolanik. Selain itu, penggunaan konkrit ringan dalam pembinaan semakin banyak dari semasa ke semasa kerana ia mempunyai daya memampatan sendiri yang tinggi dan mampu mengalir sendiri. Fokus kajian ini adalah untuk mengkaji kesan lokasi yang berlainan dalam seksyen berongga lingkaran pada kekuatan lenturan rasuk konkrit busa yang mengandungi (Process Spent Bleaching Earth), PSBE sebagai penggantian sebahagian daripada simen. Berdasarkan kajian ini, keperluan kajian ini telah dikenalpasti sebagai: i) Untuk menentukan beban maksimum lenturan lentur dengan menggunakan ujian lenturan empat titik ii) menentukan Kepada pesongan rasuk. iii) Untuk menentukan mod kegagalan rasuk lenturan. Dengan menggunakan 30% PSBE sebagai penggantian simen separa, tiga rasuk bersaiz 150mm x 200mm x 1500mm yang dilemparkan dengan seksyen berongga 50mm bulat diletakkan pada ketinggian yang berbeza dan satu rasuk kawalan dengan saiz yang sama. Ujian lenturan empat titik dilakukan untuk mendapatkan beban muktamad dan Transduser Pemindahan Variasi Linear (LVDT) digunakan untuk mengukur pesongan. Corak retak diperhatikan dan dianalisis. Keputusan eksperimen menunjukkan bahawa peratusan kehilangan kekuatan lenturan bertambah dengan peningkatan kedalaman bahagian berongga iaitu 28%, 40.79% dan 49.13% bagi Beam 2, Beam 3 dan Beam 4. Retak pertama pada rasuk dianggap sebagai retak utama sejak rasuk tidak diperkuat. Penurunan pesongan berbanding Beam 1 masing-masing adalah 5.71%, 11.43% dan 34.0% bagi Beam 2, Beam 3 dan Beam 4. Oleh itu, kekuatan lenturan dan pesongan bergantung pada momen kedua inersia yang kemudian momen inersia kedua bergantung pada paksi neutral. Secara tuntas, rasuk dengan bahagian berongga pada paksi neutral adalah rasuk yang sesuai untuk perancangan masa depan pembinaan kerana lebih tinggi beban muktamad dan defleksi. Dengan menambah tetulang dalam mana-mana aplikasi rasuk, akan lebih baik kerana beban muatan dan nilai pesongan akan lebih besar.

ABSTRACT

Nowadays construction industry focus in using green material which one of it is processed spent bleaching earth (PSBE) as pozzolan material which offer more pozzolanic reaction. Other than that, application of foamed concrete in construction getting wider from time to time as it able to have high self-compacting and self-flowing. The focus of this research is to study the effect of different location of circular hollow section on the flexural strength of foamed concrete beam containing processed spent bleaching earth as partial replacement of cement. The objectives of this research is to determine the maximum load of the flexural beam, the deflection of flexural beams and the mode of failure of the flexural beam by using four point bending test. By using 30% PSBE as partial replacement of cement, three beam sized 150mm x 200mm x 1500mm casted with 50mm circular hollow section were placed at different height and one control beam with the same size. Four point bending test were carried out to obtain the ultimate load and Linear Variable Displacement Transducer (LVDT) were used to measure the deflection. The crack pattern was observed and analyzed. The experimental result shows that Beam 2 produced greater maximum load with 3.320kN, flexural strength with 0.664 N/mm^2 and deflection with 0.330mm. The loss percentage of flexural strength increased as the depth of hollow section increased which are 28%, 40.79% and 49.13% for Beam 2, Beam 3 and Beam 4 respectively when compared to Beam 1. The decrement of deflection compared to Beam 1 are 5.71%, 11.43% and 34.0% for Beam 2, Beam 3 and Beam 4 respectively. First crack on the beam was reflected as the ultimate crack since the beam were unreinforced. Hence, the flexural strength and deflection depend on the second moment of inertia which then second moment of inertia depends on the neutral axis. In short, the beam with hollow section at the neutral axis is the suitable beam for future planning of construction due to higher ultimate load and deflection.by adding the reinforcement in any beam application, will be better because the ultimate load and deflection value will be bigger.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

σ	Flexural strength
δ	Deflection
%	Percentage

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
C-H	Calcium Hydroxide
C-S-H	Calcium Silica Hydrate
LVDT	Linear variable displacement transducer
PSBE	Processed Spent Bleaching Earth
SBE	Spent Bleaching Earth
UMP	Universiti Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 Introduction

As the demand of construction increased around the globe by year due to the rapid growth in population, the demand for concrete as the major material for construction also increase (G. Habert, 2011). Customarily, Ordinary Portland Cement that act as a binder is use to produce the concrete. Due to this, the demand for cement rose annually and the production expected to be enhance by 0.8 – 1.2% reaching to 3.7 – 4.4 billion tons in 2050 (Benhelal, Zahedi, Shamsaei, & Bahadori, 2013) The increase of cement production in number will support emission of Carbon Dioxide, CO_2 and it's amount will hit 2.34 billion tons in 2050 if no action taken(Benhelal et al., 2013)

Back in 2011, Malaysia had produced 38% of world's palm oil source and the industry had contributed over $25.04 billion USD to the national gross(Awalludin, Sulaiman, Hashim, & Aidawati, 2015). In refinery crude palm oil treatment, 10-15kg bleaching earth per tan CPO (1-1.5 mass%) used. This usage generate up to 240,000 t/yr SBE. Bleaching earth is produced in powder and it is fine in size with the contain of silicon dioxide estimated to be 57% depending on the type (Loh, Cheong, & Salimon, 2017). Micro-silica in silicon dioxide will react with calcium hydroxide in order to create more aggregate binding CSH. It work 3-5 times faster than the OPC and this will providing high early strength and durability to the concrete(Sharma, Khatri, & Kanoungo, 2014)

In addition, more researcher had come up with foamed concrete to produce lightweight concrete. In producing foamed concrete, large volume of air is entrained into the cement paste by using chemical foaming agent (Hamad, 2014). Foamed concrete had been applied in the structural building based on its density which varies, as instance

foamed concrete with density of 1200 – 1600 kg/m^3 were used as lightly loaded structural concrete application for residential building (Alsaeq, 2013). In practice, circular opening highly used in industry since it have more strength than equivalent square opening with 9% difference in ultimate capacity(Amiri & Masoudnia, 2015).

1.2 Problem Statement

In term of environmental part, the production of cement brought negative impact as 900kg CO_2 emitted to the atmosphere for production of one ton of cement. Global CO_2 emission will hit up to 234billion tons in 2050 if no action taken to reduce the activity that produce CO_2 (Benhelal et al., 2013). One of waste product that can partially replace the cement is Spent Bleaching Earth (SBE) as it contain micro silica that will help to produce aggregate binding CSH (Sharma et al., 2014). In fact, SBE is a type of material that difficult in handling and managemen. t by nature and volume generated due to lack alternative for recovery (Eliche-quesada & Corpas-iglesias, 2014). Other than that, the reduction of dead weight of the construction material using lightweight concrete will reduce the cross section of concrete structure elements such as beams, columns, plates and foundation(Tokyay & Özdemir, 1997). In present building construction transverse opening in reinforced concrete beams are frequently provided for the channel of utility pipes and ducts. In order to accommodate essential water supply, electricity and telephone lines these ducts are necessary. Passing these ducts through transverse openings in the floor beams lead to a reduction in the dead space and results in a more compact design. It is clear that presense of opening in beams changes in the sectional configuration, high stress concentration may lead to cracking unacceptable form aesthetic and durability viewpoints when the opening corner are subjected(sarah jabbar, Farzad Hejazi, 2016).

.

1.3 Objective

The purpose of this study is to investigate the effect of various position of hollow section on the strength of foamed concrete beam with processed spent bleaching earth as partial replacement of cement. The objectives are shown as below:

i. To determine the maximum load of the flexural beam by using 4 point bending test.
ii. To determine the deflection of beams.
iii. To determine the mode of failure of the flexural beam.

1.4 Scope of Study

In order to achieve the objective of this study, beams were casted and tested. The scope of this research was to study the flexural behaviour and failure characteristics. All specimen of beam were constant in length, width and height that are 1500mm, 150mm and 200mm respectively. The specimen with circular opening made up of pipe with diameter 80mm. The control beam and beam with varied in the location of circular opening which is placed as 100 mm, 150 mm and 160 mm were designated as Beam 1, Beam 2, Beam 3 and Beam 4. The density of foamed concrete is 1600kg/m^3.The simply supported beam was tested using four point bending test to get the ultimate load before the beam fail. Three linear variable data transducer (LVDT) were place along the beam and were connect to data logger to get the deflection. The crack propagated and crack pattern were observed during the testing

1.5 Significance of Study

Based on this study, the flexural beams with different location of circular hollow were fabricated and tested by using four point bending test to get the maximum load. Carbon dioxide from cement industry gave the highest contribution to global warming phenomenon. Thus, it is a priority to find the approaches to mitigate CO_2 emission to subside the threat of climate change. In order to that, waste product from oil refinery stage which is Processed Spent Bleaching Earth (PSBE) can be apply to partial replace the cement content in a concrete. Moreover, the use of PSBE as a waste product can solve the landfill disposal problem. The usage of foamed concrete which can minimised the

REFERENCES

Abou-Zeid, Mohamed, David W. Fowler, Edward G. Nawy, & John H. Allen. (2001). Control of Cracking in Concrete Structures. *ACI 224R-01,Reported by ACI Committee 224*, (October), 1–8. https://doi.org/0097-8515

Alsaeq, H. M. (2013). Effects of Opening Shape and Location on the Structural Strength of R . C . Deep Beams with Openings, *7*(6), 494–499.

Alsubari, B., Shafigh, P., & Jumaat, M. (2015). Development of Self-Consolidating High Strength Concrete Incorporating Treated Palm Oil Fuel Ash. *Materials*, *8*(5), 2154–2173. https://doi.org/10.3390/ma8052154

Altun, F., Haktanir, T., & Ari, K. (2007). Effects of steel fiber addition on mechanical properties of concrete and RC beams. *Construction and Building Materials*. https://doi.org/10.1016/j.conbuildmat.2005.12.006

Amiri, S., & Masoudnia, R. (2015). Investigation of the Oppening Effects on the Behavior of Concrete Beams Without Additional Reinforcement in Opening Region Using Fem Method Investigation of the Oppening Effects on the Behavior of Concrete Beams Without Additional Reinforcement in Opening, (October). https://doi.org/10.13140/RG.2.1.2108.1041

Awalludin, M. F., Sulaiman, O., Hashim, R., & Aidawati, W. N. (2015). An overview of the oil palm industry in Malaysia and its waste utilization through thermochemical conversion , speci fi cally via liquefaction. *Renewable and Sustainable Energy Reviews*, *50*, 1469–1484. https://doi.org/10.1016/j.rser.2015.05.085

Benhelal, E., Zahedi, G., Shamsaei, E., & Bahadori, A. (2013). Global strategies and potentials to curb CO2 emissions in cement industry. *Journal of Cleaner Production*, *51*, 142–161. https://doi.org/10.1016/j.jclepro.2012.10.049

Eliche-quesada, D., & Corpas-iglesias, F. A. (2014). Utilisation of spent fi ltration earth or spent bleaching earth from the oil re fi nery industry in clay products. *Ceramics International*, *40*(10), 16677–16687. https://doi.org/10.1016/j.ceramint.2014.08.030

Finazzi, S. Paegle, I. Fischer, G. M. (2014). Influence of bending test configuration on cracking behavior of FRC Influence of bending test configuration on cracking behavior of FRC Materials.

Hamad, A. J. (2014). Materials , Production , Properties and Application of Aerated

Lightweight Concrete : Review, *2*(2), 152–157. https://doi.org/10.12720/ijmse.2.2.152-157

Hassan, K. E., Cabrera, J. G., & Maliehe, R. S. (2000). The effect of mineral admixtures on the properties of high-performance concrete. *Cement and Concrete Composites*, *22*(4), 267–271. https://doi.org/10.1016/S0958-9465(00)00031-7

Jones, M. R., & McCarthy, A. (2005). Preliminary views on the potential of foamed concrete as a structural material. *Magazine of Concrete Research*, *57*(1), 21–31. https://doi.org/10.1680/macr.2005.57.1.21

Kristiawan, S., Supriyadi, A., Sangadji, S., & Santosa, D. (2017). Cracking behaviour and its effect on the deflection of patched-reinforced concrete beam under flexural loading. *6th International Conference of Euro Asia Civil Engineering Forum, EACEF 2017*, *138*. https://doi.org/10.1051/matecconf/201713802021

Lignola, G. P., Prota, A., Manfredi, G., & Cosenza, E. (2007). Deformability of reinforced concrete hollow columns confined with CFRP. *ACI Structural Journal*, *104*(5), 629–637. https://doi.org/10.1061/(ASCE)1090-0268(2007)11:1(42)

Loh, S. K., Cheong, K. Y., & Salimon, J. (2017). Surface-active physicochemical characteristics of spent bleaching earth on soil-plant interaction and water-nutrient uptake: A review. *Applied Clay Science*, *140*, 59–65. https://doi.org/10.1016/j.clay.2017.01.024

Loh, S. K., James, S., Ngatiman, M., Cheong, K. Y., Choo, Y. M., & Lim, W. S. (2013). Enhancement of palm oil refinery waste - Spent bleaching earth (SBE) into bio organic fertilizer and their effects on crop biomass growth. *Industrial Crops and Products*, *49*, 775–781. https://doi.org/10.1016/j.indcrop.2013.06.016

Malesza, J. (2013). Identification of bending moment in semi-fixed beam. *Procedia Engineering*, *57*, 746–753. https://doi.org/10.1016/j.proeng.2013.04.094

Mansur, M. A. (2006). DESIGN OF REINFORCED CONCRETE BEAMS WITH WEB OPENINGS, 5–6.

Mohd.Ismail, H. K., Fathi, M. S., & Manaf, N. bte. (2004). Study of Lightweight Concrete Behaviour. *Universiti Teknologi Malaysia*, 1–28.

Narayanan, N., & Ramamurthy, K. (2000). Structure and properties of aerated concrete : a review, *22*, 321–329.

Neville, A. M. (2011). *Properties of Concrete*. *Journal of General Microbiology* (Vol. Fourth). https://doi.org/10.4135/9781412975704.n88

Parmar, H., Kumar, D., Kumar, R., & Dave, N. (n.d.). Flexural Strength of Concrete Beam By Partial Replacement of Cement with Fly Ash And Silica Fume. *Journal of Structural Technology*, *2*(2).

Ramamurthy, K., Kunhanandan Nambiar, E. K., & Indu Siva Ranjani, G. (2009). A classification of studies on properties of foam concrete. *Cement and Concrete Composites*, *31*(6), 388–396. https://doi.org/10.1016/j.cemconcomp.2009.04.006

sarah jabbar, Farzad Hejazi, H. M. M. (2016). Effect of an Opening on Reinforced Concrete Hollow Beam Web Under Torsional , Flexural , and Cyclic Loadings, 1576–1595.

Sharma, U., Khatri, A., & Kanoungo, A. (2014). Use of Micro-silica as Additive to Concrete-state of Art, *5*(1), 9–12.

Spriestersbach, D., Grad, P., & Kerscher, E. (2014). Crack initiation mechanisms and threshold values of very high cycle fatigue failure of high strength steels. *Procedia Engineering*, *74*(0), 84–91. https://doi.org/10.1016/j.proeng.2014.06.229

Tang, W. C., Balendran, R. V., Nadeem, A., & Leung, H. Y. (2006). Flexural strengthening of reinforced lightweight polystyrene aggregate concrete beams with near-surface mounted GFRP bars. *Building and Environment*, *41*(10), 1381–1393. https://doi.org/10.1016/j.buildenv.2005.05.029

Tokyay, M., & Özdemir, M. (1997). Specimen shape and size effect on the compressive strength of higher strength concrete. *Cement and Concrete Composites*, *27*(8), 1281–1289. https://doi.org/10.1016/S0008-8846(97)00104-X

V.S.Satheesh, S.Sivanadiyan, H.Soniya, M.Sridhar, R. S. V. A. (2017). RESEARCH ARTICLE ISSN : 2321-7758 FLEXURAL BEHAVIOUR OF FIBER REINFORCED HOLLOW SQUARE BEAM, *5*(2), 139–146.

Venkateshappa, S. C., Bennehalli, B., Kenchappa, M. G., & Ranganagowda, R. P. G. (2010). Flexural behaviour of areca fibers composites. *BioResources*, *5*(3), 1846–1858. https://doi.org/10.15376/biores.5.3.1846-1858